as he tells us, with the importance of this investigation, and then and there devoted the efforts of his whole life to carry it out. Accordingly, in 1832 he presented a very extensive work to the Academy of Sciences, a report on which, by MM. Gay-Lussac and Becquerel, is annexed to the volume before us.

The ideas developed in this work were derived from two sources—crystallography and chemistry. Haüy had endeavoured to explain the regularity of the forms of crystals by regarding them as built up of molecules, the form of each molecule being similar to that of the simplest solid which can be obtained from the crystal by cleavage. The absolute size of these integrant molecules, as they were called, was left, of course, indeterminate.

Wollaston preferred to regard the arrangement of the ultimate molecules in a crystal as resulting, not from their accurately fitting one another as bricks do in a wall, but from their tendency to crowd together into the smallest possible volume as peas do in a bag. The form of the molecules, according to Wollaston, was not polygonal, but spherical or ellipsoidal.

At this point Ampère took up the theory. His atoms were no longer either closely fitted together, or even touching one another at isolated points, but were maintained by attractive and repulsive forces at distances exceedingly great compared with their own dimensions. The forms of the atoms themselves were therefore no longer considered as of any importance; the molecules, formed of groups of these atoms, were represented in diagrams as systems of points; and the explanation of the geometrical properties of the substance in the crystalline form was sought in the geometrical arrangement of these atoms.

The proportions in which the atoms of different kinds were to be represented in the molecules were determined in accordance with the atomic theory of chemistry, established by Dalton, and the absolute number of such atoms in the molecule was arranged so as to satisfy the law of gases, recently discovered by Gay Lussac, which asserts that the mass of every gaseous molecule is proportional to the specific gravity of the gas at the standard pressure and temperature.

The theory of M. Gaudin may be regarded as founded upon that of Ampère, with certain modifications. Instead of assuming with Ampère, that when two molecules combine, the form of the compound molecule is the resultant of the forms of its components, he supposes that the atoms of the combining molecules are all thrown into a common stock, to be arranged, according to some principle of equilibrium or of symmetry, in a form having no necessary relation to the forms of the combining molecules.

In the work before us M. Gaudin gives us, as the result of his long-continued meditation on compound molecules, actual diagrams of their supposed forms, showing not only their outward shape, but the arrangement of the molecules in each of the layers in which they are disposed. The ingenuity with which he has arranged in a symmetrical manner groups sometimes amounting to 279 atoms must be seen in order to be appreciated. But the merit of these arrangements as an explanation of facts must be tested, first by a careful comparison of those forms whose chemical relations are similar, and then by a comparison of each diagram with the crystallographic properties of the substance which it is supposed to represent. The author has, to the best of his ability, applied both these tests, and we shall not here pronounce sentence upon the result of such an examination.

We may remark, however, that M. Gaudin began his labours forty years ago, using the methods of investigation which we have briefly described. Since that time he has been patiently arranging his atoms by rows and groups, and representing them in models by means of pearls of various hues. He has shown no symptom of being attracted towards any of those newer paths which Joule, Clausius, and others have opened up into the higher regions of kinetic molecular science. Indeed we not only find no mention of the names of any of these men, but we look in vain for any indication of a desire to pass beyond mere geometrical arrangements of atoms, and to inquire into the forces with which they act on each other or the motions with which they are agitated. There is a chapter, indeed, entitled "Hémiédrie et pouvoir rotatoire," but though there is something about hemihedry, there is nothing there at all about the power of rotating the plane of polarisation of light. The only piece of dynamics in the book is the theory of capillary phenomena at p. 197, about which the less we say the better.

M. Gaudin is favourably known to science as an adept in the management of the blow-pipe. He has melted the most refractory bodies, and compounded the oriental ruby from its elements. He has not only established the chemical formula of silica and modelled its molecule, but he has fused quartz into beads, and drawn it into threads like spun glass.

His experimental researches have displayed great ingenuity and manipulative skill, but have often been brought to an untimely end for want of funds to carry them on. In his theoretical speculations he has been guided by geometry alone, without the powerful if not absolutely necessary aid of dynamics; and in the great work of his life he has met with very little encouragement, and has been sustained only by his conviction of the scientific value of the treasure of which he is in search.

OUR BOOK SHELF

A Manual of Photography. By George Dawson, M.A. Eighth edition. (J. and A. Churchill.)

THE new edition of this excellent manual of photography, which is founded on and incorporates as much of Hardwick's "Photographic Chemistry" as is valuable in the present further advanced stage of the art, retains its position as the best work on the subject for amateurs, as well as professionals. The many new methods and materials which are so frequently being introduced, make it essential that any book professing to keep up to the times must be frequently revised, and Dr. Dawson has in this work presented the subject in its most advanced position. The earlier chapters, after giving a short sketch of the history of photography, enter into a description of the most important experiments, the expansion of which make up the subject itself. This is followed by a review of the various lenses required for the many different purposes to which photography is applied, and their peculiarities are rendered more evident by the introduction of very clear diagrams of them in section. After a full description of the various points connected with the wet-plate

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collodion process, considerable space is devoted to the more modern subject of dry-plate photography. The many precautions necessary in the employment of the collodio-bromide negative process, as introduced by Messrs. Sayce and Bolton, and improved by Mr. Carey Lea and Colonel Wortley, are fully entered into; and the very rapid method introduced by the latter gentleman, in which the collodion is saturated with nitrate of silver, is given with some very recent formulæ. The subject of printing in pigments, so important in the present day, which "doubtless would become universal were the processes unfettered by patents," is fully described, with the difficulties attending the "double transfer" of the gelatin film. Following the details of photolithography, photozincography is that of collotype printing, which has become so prominent of late. A vocabulary of chemicals ends this valuable and suggestive work, of which, from want of space, we have had to omit the mention of many points.

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. No notice is taken of anonymous communications.*]

Science at Cambridge

THERE are some points in two articles which have lately appeared in your periodical upon which I should like to make a few remarks. First, however, allow me to congratulate the author upon having deprived the opponents of "Science" of a time-honoured monopoly. For a certain quiet insolence of conscious superiority and an inability to see more than one side of a question, his articles equal any diatribes that I have heard or read from the most intolerant supporter of "the old ecclesiasticism and false culture."

Let that pass, however, and let us proceed to examine one or two statements in detail. "Science is all but dead in England, . . . perhaps deadest of all at our Universities." Now on reading the word science, one has always to ask what a writer means, and the probability is that he means what is commonly called natural science; our writer, however, kindly gives us a definition—"that searching after new knowledge which is its own reward."

Most certainly the more eminent among our Professors and resident Fellows (and some of them are known even in Germany) cannot be said to have followed learning for any other reward; or if so they have taken their pigs to a very poor market. He will, perhaps, say that they have fellowships and professorships. Yes, the aggregate value of which will vary from probably six to nine hundred a year, coupled, in some cases, with conditions which seriously diminish their value. Is this so great a prize?

Again, we are represented as encouraging by prize fellowships and "that kind of liberal education which softens the character and prevents it being strong." I hardly know what the writer means; however, the following are the studies which we do endeavour to encourage:—

(1.) Mathematics.—Does the writer seriously mean to apply his remark to this study? If so, I can only say that to those who can appreciate sound and unsound reasoning, there is a marvellous difference between the work of (say) such a geologist as the late Prof. Sedgwick, trained in the school of mathematics, and not a few, whom it would be offensive to name, who have never had that advantage.

(2.) Language.—Perhaps in comparison with looking at mites in a microscope, or analysing some very rare but useless mineral, the attempt to enter into communion with the thought of the master-minds of our race in the past time is a contemptible pursuit; but though with a great regard for both the above pursuits myself, and with no pretension to refined scholarship, I cannot—and hope but few can—agree with this opinion.

(3.) The moral sciences.—If this is meant, I give the writer over to the tender mercies of the philosopher, who, I think, will be able to give an account of him: so also as regards legal studies.

(4.) Natural Sciences.—These are encouraged in precisely the same way as the others (in the case of most colleges). Is this then culture which produces effeminacy?

But perhaps the writer will say that only classics and mathematics are encouraged. To this I reply that the other studies are of recent growth in the University—I admit that they ought to have taken root long ago—that however is not our critic's charge—he is dealing with the present—and I have no hesitation in affirming that in all the important colleges the students of natural science have just as good a chance of honour and rewards as those of other branches of learning. The number of rewards that have been given is small, because the number of really first-class students has hitherto been small. The number of students (and their quality) increases year by year. I have no fear that as a rule they will meet with their deserts.

Or does the writer mean to say that our fault is teaching and examining, that we ought to open laboratories (for notwithstanding his definition, I think his science means only one thing) and simply exercise a general superintendence over students? After an experience of some years I can only say that though I do not worship either lectures or examinations (especially the latter), with a blind "idolatry," I believe without them the majority of young students are very apt to become slipshod and slovenly in their work.

But the trumpet's sound is so uncertain that I know not exactly what the writer does mean. I have read over and over again his *tertium quid* (p. 41), in supporting which he confesses he is with a select few—doubtless the salt of the earth—and I still am doubtful. They be very "brave words"—but "to make the University a place where anyone and everyone may be trained for any and every respectable path of life," is just the aim of every change that has been made since I have known the place. Our students—of subjects not classical—certainly increase yearly, and I have not heard of any marked deportation to the Elysian fields of either Manchester, London, Newcastle, or Germany. Neither have I found that such "master minds of the age" as are within our walls (and I think, subject to the writer's approval there are some) inaccessible to students.

In conclusion I must state in self-defence that I am not usually considered a conservative. I have done all that was in my power to help the cause of University Reform, and especially of Natural Science. But much as I delight in the latter I decline to regard it as the only culture, the only training worthy of respect. I trust to live to see yet greater changes. These however will not be obtained by vague declamations or reckless accusations—such as "long years of misrule have left suckers of jobbery, like bind-weed in an old garden, which come up refreshed with every stirring of the soil." After twelve years of active life in the University—and often failing to obtain what I wanted—I unhesitatingly assert that there is no place where there is so little jobbery, or where the motives that actuate men, even if mistaken, are so generally pure as here. There are jobs everywhere now and then, even in scientific societies or coteries.

There are indeed difficulties in the way of reform, but the writer of the articles, I venture to think, has not hit the nail on the head. May I, before ending this long letter, in a few words indicate one or two—1. The workers in the University should govern it. At present a body called the Senate, 'consisting chiefly of non-residents, has the final decision of everything. Throw all the power into the hands of the working bees, and we will reform ourselves fast enough. 2. The waste of money in non-resident fellowships. There are very few here who would defend the present system, but we have no power to change it ourselves. 3. The poverty of the Universities. To relieve this we must have power given to colleges to alter their statutes, and so long as the University is governed by the Senate, we in the colleges do not care to put beyond our control funds which might then even be applied to political or theological squabbles. 4. An improvement of the Professorial System—more teachers and rather less routine work, with greater unity of action between the former. Give us powers, and we will soon settle that. We are bound, like the Jews, "by a chain of ordinances," and till that is broken cannot help ourselves. T. G. BONNEY

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Arctic Exploration

THE news of Mr. Hall's Arctic Exploration is important from two points of view, and I shall be obliged if you will allow me the space to point out the lessons to be derived from it, and the way in which the new facts strengthen the arguments for Polar exploration.

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